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Forced Air-Drying of Southern Pine Lumber

by

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Seasoning is one of the most important steps in processing lumber for market. If lumber is air-dried, it becomes the most time-consuming step, often requiring many months and large inventories in order to assure supplies of adequately dried lumber to meet the market at the time required by the buyer.

The rate at which lumber can be dried by conventional air-drying depends almost entirely on the weather, and little can be done to alter the process once the lumber is stacked and placed to dry. The drying season in most localities seldom exceeds six months out of the year because of rainy seasons and cold weather. Fast air-drying occurs only when the periods of high temperatures and low humidities coincide, and this optimum coincidence usually happens during part of spring, summer, and fall. During cold or damp weather it may take many times longer to dry lumber to a satisfactory moisture content; sometimes it becomes impossible to dry to a given final moisture content because of the continual setbacks resulting from intermittent rains.

Degrade is also a problem on the drying yard. Most lumberyard operators expect it on the upper courses of lumber in a pile. Additional degrading occurs down through the pile, depending on stacking method, location, weather conditions, time required to dry certain species, and other factors.

The time and inventory required and the degrade losses involved in conventional air-drying methods are sufficient justification to warrant study on improved processes. Forced air-drying is one method for reducing the drying time, for scheduling drying within predetermined periods of time, and for minimizing degrade. Some forced air-drying is being used by the lumber industry with good results. Drying time has been reduced, flatter and brighter stock is reported, and costs appear to be in line with conventional yard air-drying when the lumber grade savings and improvements are balanced against the time and cost of carrying large inventories of lumber over unpredictable periods.

Forced air-drying of lumber is a method for seasoning green wood (from 30 to 300 percent moisture content) to about 20 percent moisture content by means of forced air circulation with low heat if conditions require it.[2] One method utilizes large buildings constructed of low cost materials and equipped with large fans, a venting system, and sometimes a means of providing supplemental heat. Air makes one pass through the lumber in unheated buildings, but it is recirculated when heat is used. Another method uses large mobile fans to push or pull air through lumber piles located on the yard, and the air is always at the prevailing yard temperatures and relative humidities.

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[1] Technologist, Athens Branch of the Macon Research Center, maintained by the Southeastern Forest Experiment Station in cooperation with the School of Forestry, University of Georgia.

The primary objectives of this study were to test variables of weather, air velocities, and supplemental heat as they affect the drying of southern pine lumber. Secondary objectives were the determination of the amount of seasoning degrade, the uniformity of moisture content, the relation of air velocities and drying time to fan power consumption, and the effect of length of air travel on drying uniformity and degrade.

TEST EQUIPMENT USED

A small commercial-size dry kiln was used when controlled minimum temperature or controlled EMC[3] conditions were desired (fig. 1). This kiln has a capacity of approximately 6 M board feet. In addition to the usual dry kiln recorder-controller, other instruments were installed for various tests: a wood-element hygrostat[4] to control equilibrium moisture content to maximum set points, a watt-hour meter to measure power consumption of the fan motor, and three additional recorders placed inside and outside the kiln to provide hourly data on temperature and relative humidity. The dry kiln was used for its accurate control features and any reference to tests in the dry kiln refer to forced air-drying.

Information was also taken from three small wind tunnels, constructed to supplement the kiln data and to provide information which could not be obtained in the kiln. Each tunnel is 4 feet square in cross section, and the length can be extended from the basic 8 feet to longer lengths. Ambient air is pulled through the load in the tunnel by a fan 44 inches in diameter without recirculation (fig. 2). An open shed protects the tunnels from rain and permits free movement of air. A hygrothermograph provides a continuous record of temperatures and relative humidities of the air entering the tunnels.

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[2] Similar methods are called fan air-drying and predrying. The term "predrying" was coined by the Australians who used this method to reduce the moisture content of lumber to the fiber saturation point (about 30 percent). The lumber was then placed in kilns for final drying.

[3] Wood gives off or absorbs moisture, depending upon the relative humidity and temperature in which it is exposed. The point at which wood neither loses nor gains moisture is a balance point reached with the atmosphere and is known as the wood equilibrium moisture content. It is closely related to relative humidity.

[4] Johnson, Seymour J., and Rasmussen, E. F. A Wood-Element Hygrostat. U. S. Forest Serv. Forest Prod. Lab. Rpt. 1602. 1959.

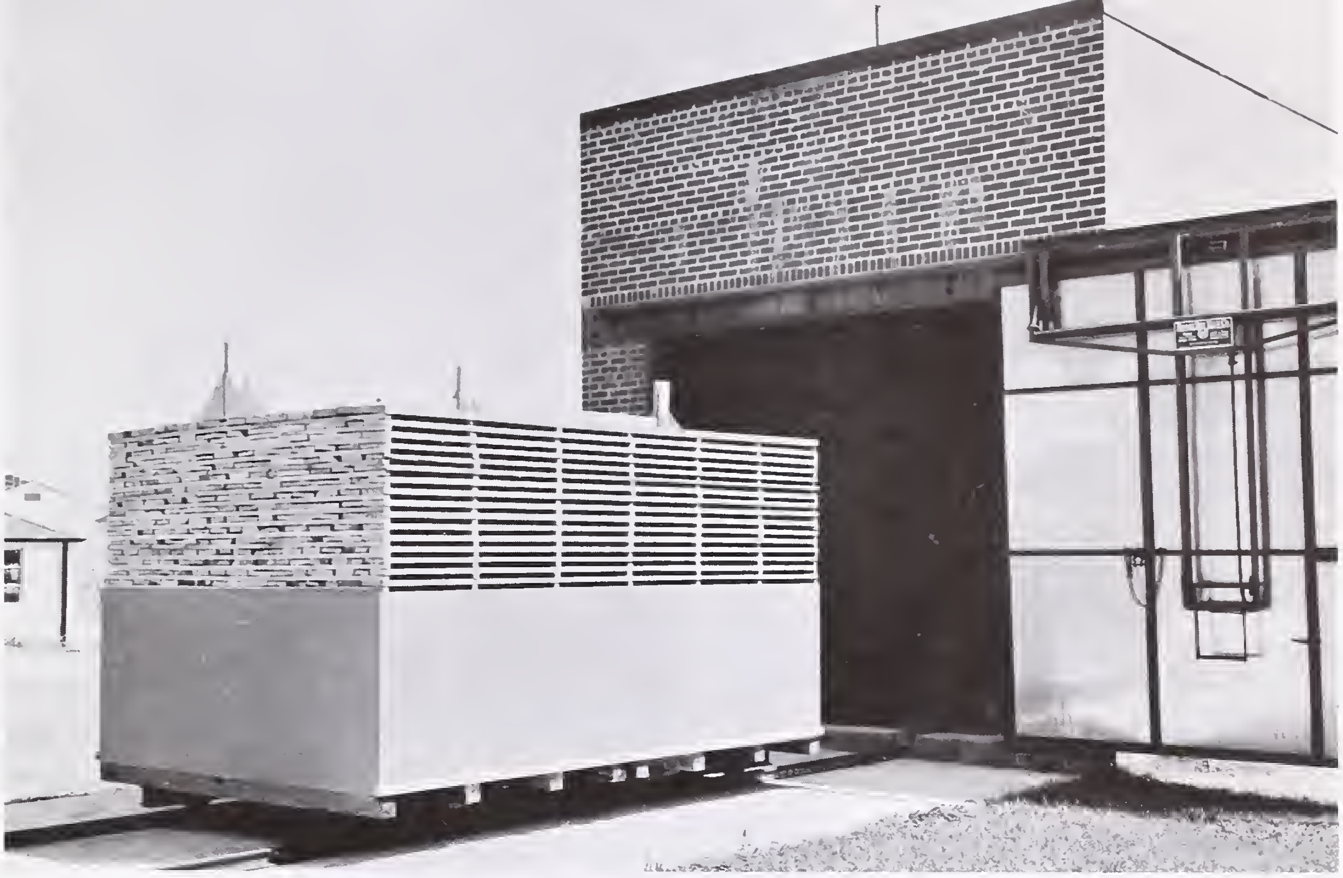

Figure 1.--Load ready for drying in the modified test kiln located at the George Foster Peabody School of Forestry, University of Georgia, Athens, Georgia.

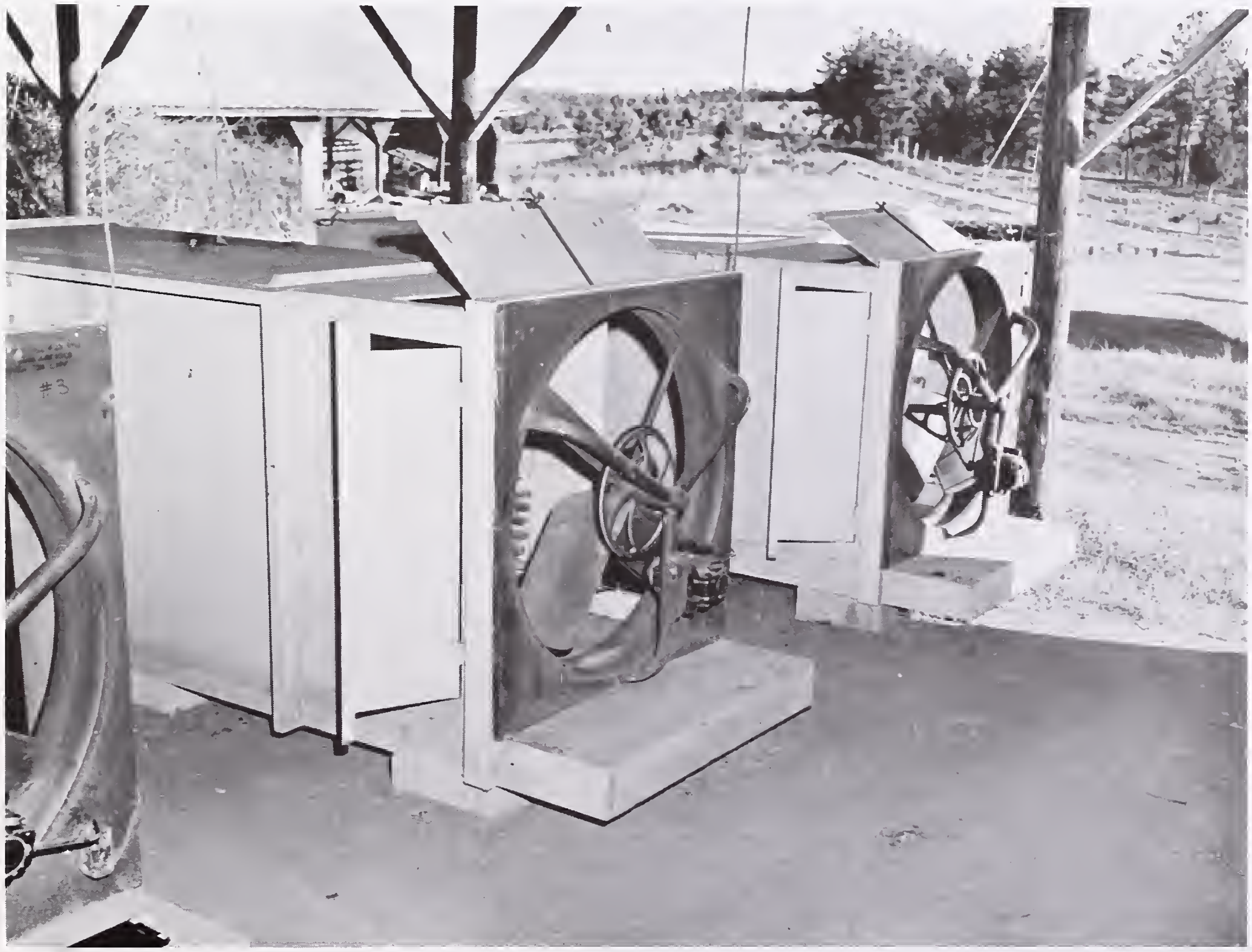

Figure 2.--Experimental wind tunnels for drying tests.

TEST PROCEDURE

Dry Kiln

For tests in the kiln, uniform loads of 15 courses of rough green pine lumber (about 1,300 board feet when using 4/4) were piled on a dummy base to reduce the amount of lumber for a single test. Each course was 8 feet wide and 12 feet long and was made up of 14 or 15 boards. The boards were piled edge to edge on 1-inch-thick stickers placed 2 feet apart.

A minimum of six sample boards was placed in each side of the kiln loads to determine daily moisture content. These samples were selected from the greenest material within thickness limits of 1 to $1\frac{1}{8}$ inches for 4/4, and 2 to $2\frac{1}{8}$ inches for 8/4. In addition to being used for determining daily moisture content, these sample boards were used at the end of the test to check calculated moisture content and final moisture content.

Average air velocities of 200, 600, and 1,000 feet per minute in the kiln were obtained by varying the number of fans (table 1). The actual average air velocity for each test, however, was determined by measuring the velocity in each sticker opening on the air-exit side of the load (fig. 3). Measurements were made with a thermo-anemometer soon after the test was begun in order to adjust for any large differences in velocities. Length of air travel was 8 feet for each test and air direction was reversed every 3 hours.

Table 1.--Typical air velocity variations obtained in kiln tests

Fans used (number)	Range of velocities	Mean velocity	Standard deviation	Coefficient of variation
	Feet per minute	Feet per minute	Feet per minute	Percent
1	120-250	187	22	11.8
2	450-650	573	45	7.9
3	900-1100	994	57	5.7

Tests conducted at a constant 80° F. setting during the fall and winter months in Athens, Georgia, required supplemental heat, whereas little or none was needed during spring and summer. For other kiln tests under equilibrium moisture content control, the temperature was permitted to vary as required to maintain the desired EMC through the use of a wood-element hygrostat. Vents were open continuously during all tests.

Control of the maximum EMC in the kiln was done with a wood-element hygrostat which operates on the principle that wood gives off and absorbs moisture with changes in EMC (fig. 4). These changes cause the wood element to shrink or swell. The shrinking and swelling action is utilized to automatically supply additional heat when the EMC rises above the setting. Maximum EMC was limited in these tests to various percentages ranging from 9 to 13.

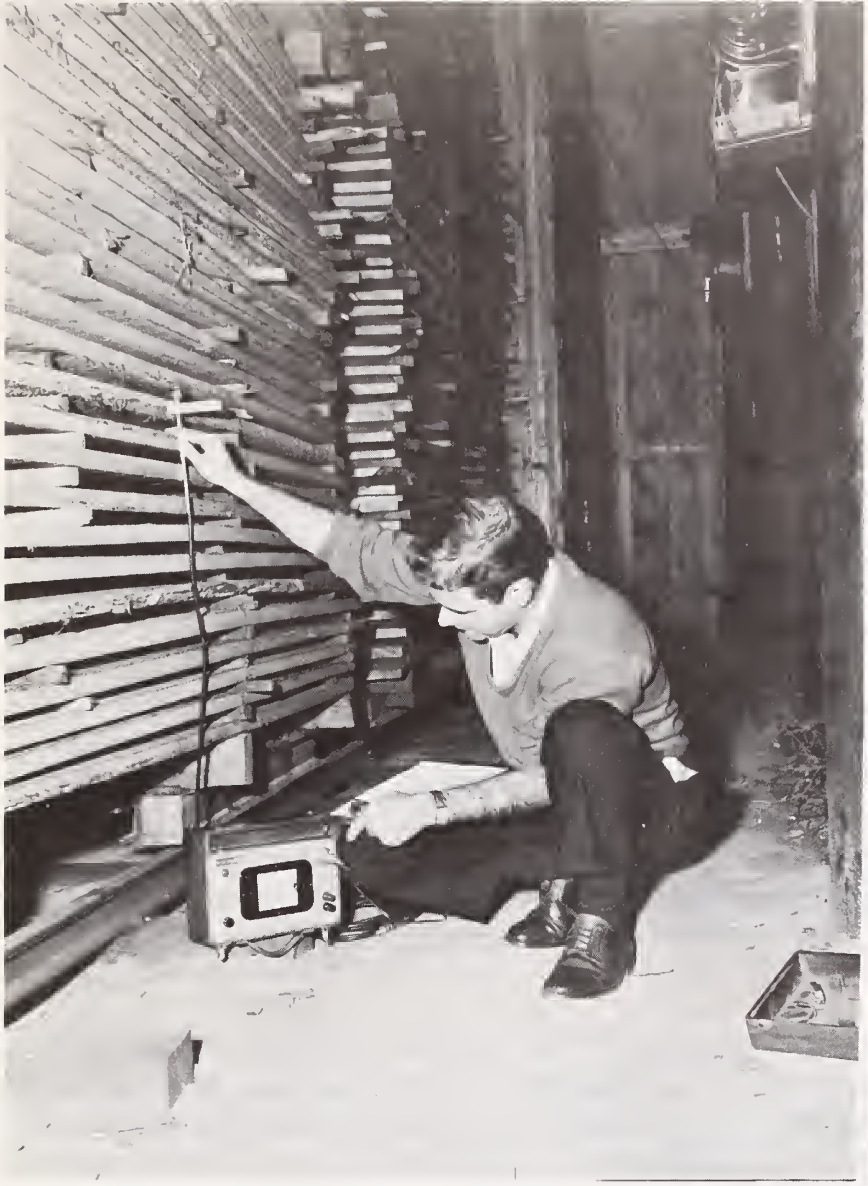

Figure 3.--Measuring air speed with a velometer on the exit side of the load in a forced air-drier.

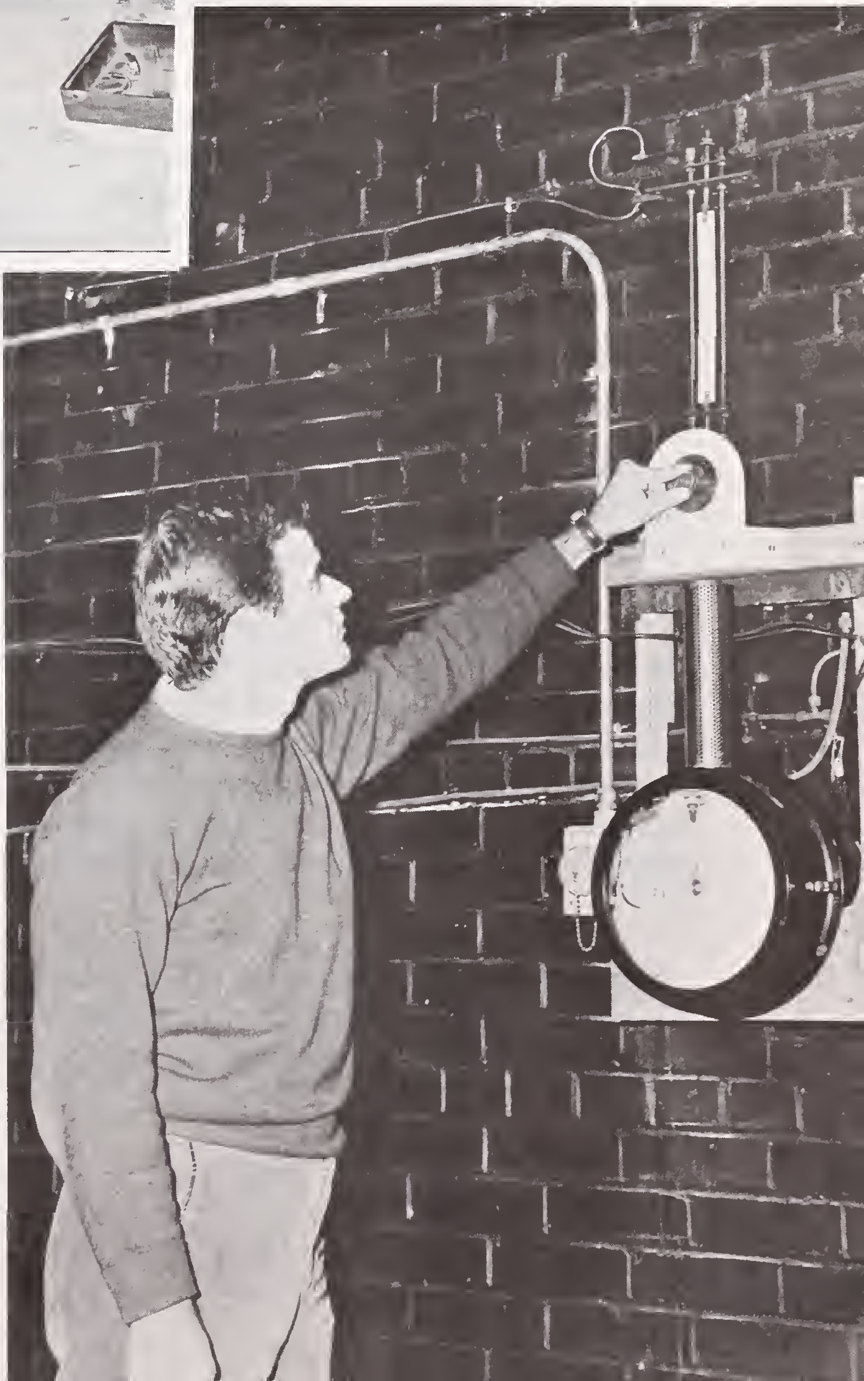

Figure 4.-- EMC is controlled by wood-element hygrostat mounted here above the temperature recorder-controller.

During all tests with EMC control, air velocity was maintained at approximately 600 feet per minute.

After each test in the kiln every board was graded twice. In the first round of grading, seasoning defects were ignored; in the second grading,they were considered. Causes for degrade were recorded, according to the limitations specified in the grading rules of the Southern Pine Inspection Bureau.

In addition to the moisture content information obtained from sample boards, the final moisture content of every board in kiln tests was checked with an electric moisture meter. Readings were taken in the center of each board and an average final moisture content determined for each load.

Seven tests were conducted in the kiln at a constant temperature of 80° F. with controlled average air velocities of either 200, 600, or 1,000 feet per minute. Four tests at 80° F. and air velocities of approximately 600 feet per minute were conducted to compare 4/4 and 8/4 lumber dried together. Six tests were made holding air velocity constant at approximately 600 feet per minute and controlling maximum EMC between 9 and 13 percent. Power consumption data was obtained for all tests conducted in the kiln.

Wind Tunnels

No control of temperature, EMC, venting, or recirculation was attempted in the tunnels. Tests were limited to air velocities and length of air travel as they affected drying time.

In the tunnel tests, 22 courses of 4/4 boards 4 feet long were piled edge to edge on 1-inch stickers for the basic 8-foot length of the tunnel. The middle 6 courses constituted the test section and were made up of green lumber. The 2 center courses in the test section contained full-length moisture sample boards and provided all the test data. Two courses above and below the sample courses provided a buffer zone of green lumber to insure that green material surrounded the sample boards.

Sample boards for the tunnel tests were selected in the same manner as those in the kiln tests. Each tunnel contained 2 courses in which every other board was a sample board for a total of 14 samples per tunnel when the basic tunnel length (8 feet) was used. To eliminate differences between sample boards, three 4-foot samples were cut from the same board and distributed among the three tunnels for the same location. The samples were weighed daily and retained at the end of the tests for further analysis.

Air velocities of 300, 550, and 800 feet per minute in the three tunnels were obtained by changing the fan pulley ratios and the air by-pass openings as necessary. Length of air travel tests were conducted in a 16-foot tunnel using a constant air velocity of approximately 500 feet per minute.

The simultaneous testing of drying rates at air velocities of 300, 550, and 800 feet per minute in the three wind tunnels was replicated three times. Two tests were conducted to determine variation in drying rates as affected by length of air travel.

RESULTS AND ANALYSIS

The results of these forced air-drying tests did not disclose any new principles useful in removing moisture from wood, but they did confirm some well known facts and provided data which should permit drying of southern pine in predetermined drying periods for various operating conditions.

Temperature

The drying rate of wood, like that of similar hygroscopic materials, is directly related to the diffusion rate of moisture from the core to the surface. Increasing the temperature of the wood causes an increase in vapor pressure and the diffusion rate is quickened. Low temperatures (i.e., below 70° F.), therefore, cannot be expected to produce fast lumber drying, all other factors being equal. This is well illustrated in the wind tunnel tests conducted during spring and winter.

When 4/4 pine was dried from green to an average moisture content of 25 percent, drying times varied from 4.4 to 7.5 days in the spring months (average 72° F.) to 7.0 to 12.0 days in the winter (average 42° F.). The same air velocities were used both times (fig. 5). During the winter a definite reduction in drying rate took place at about 25 percent, and any attempt to dry below 25 percent moisture content during cold weather without some additional heat is probably not practical for southern pine lumber.

In the kiln tests, with temperature held at 80° F., drying time for 4/4 pine from green to an average moisture content of 17 percent did not exceed 9.5 days for various air velocities tested during all seasons of the year, thus illustrating the importance of a minimum temperature (fig. 6). Drying time for 8/4 pine ranged from 10.5 to 14.7 days when drying to 17 percent using 80° F. temperature control and an air velocity of approximately 600 f.p.m. (fig. 7). This was twice the average drying time for 4/4 pine.

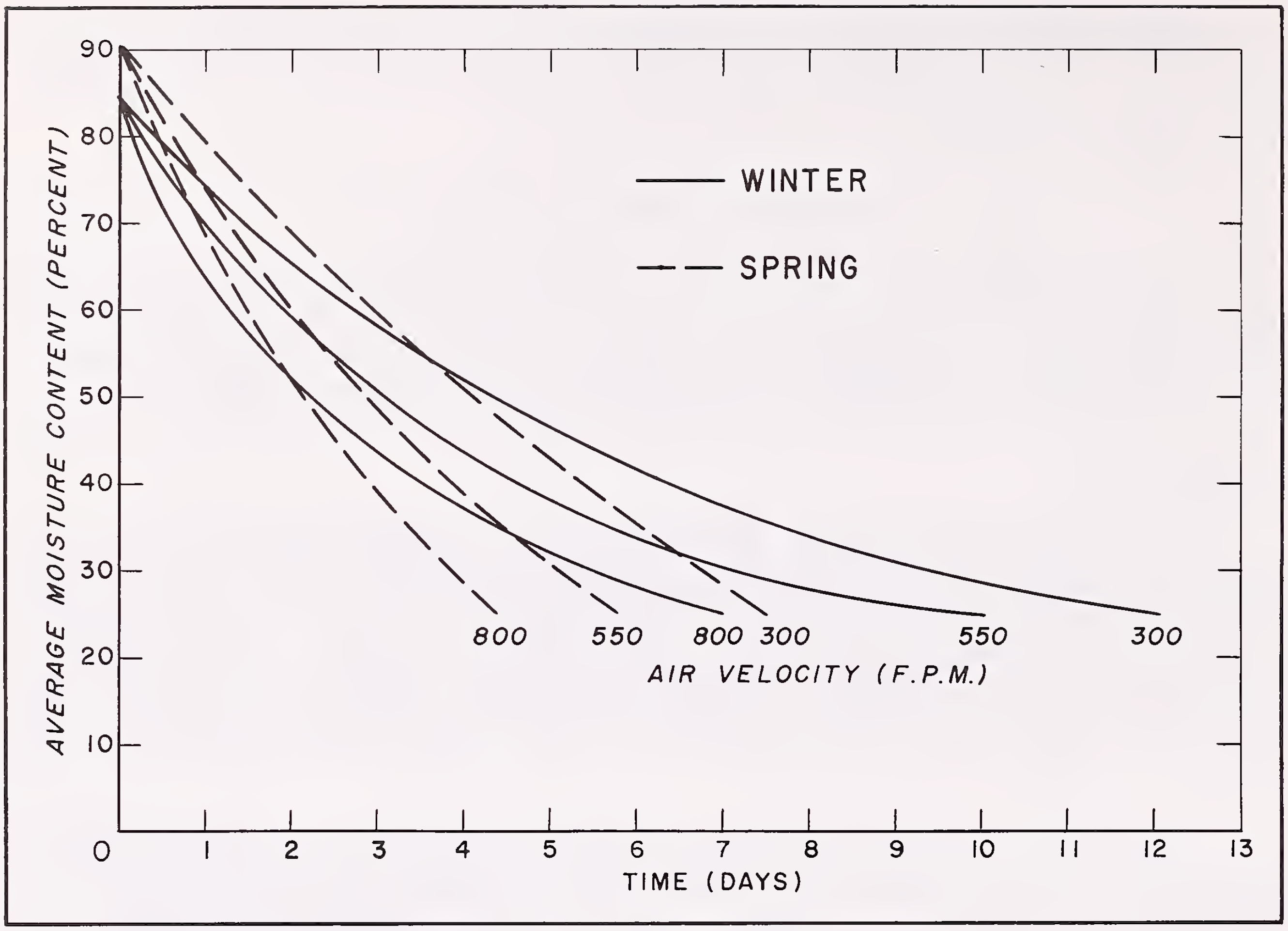

Figure 5.--Effect of air velocity on drying time of 4/4 pine in wind tunnels during spring and winter.

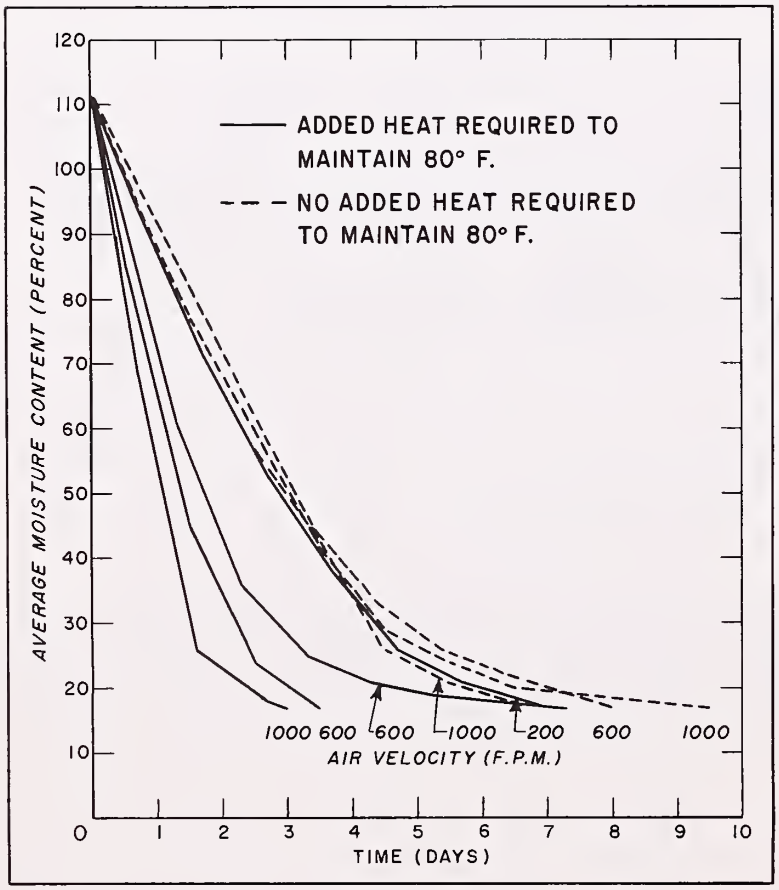

Figure 6.--Pine lumber (4/4) dried at three air velocities and constant temperature (80° F.).

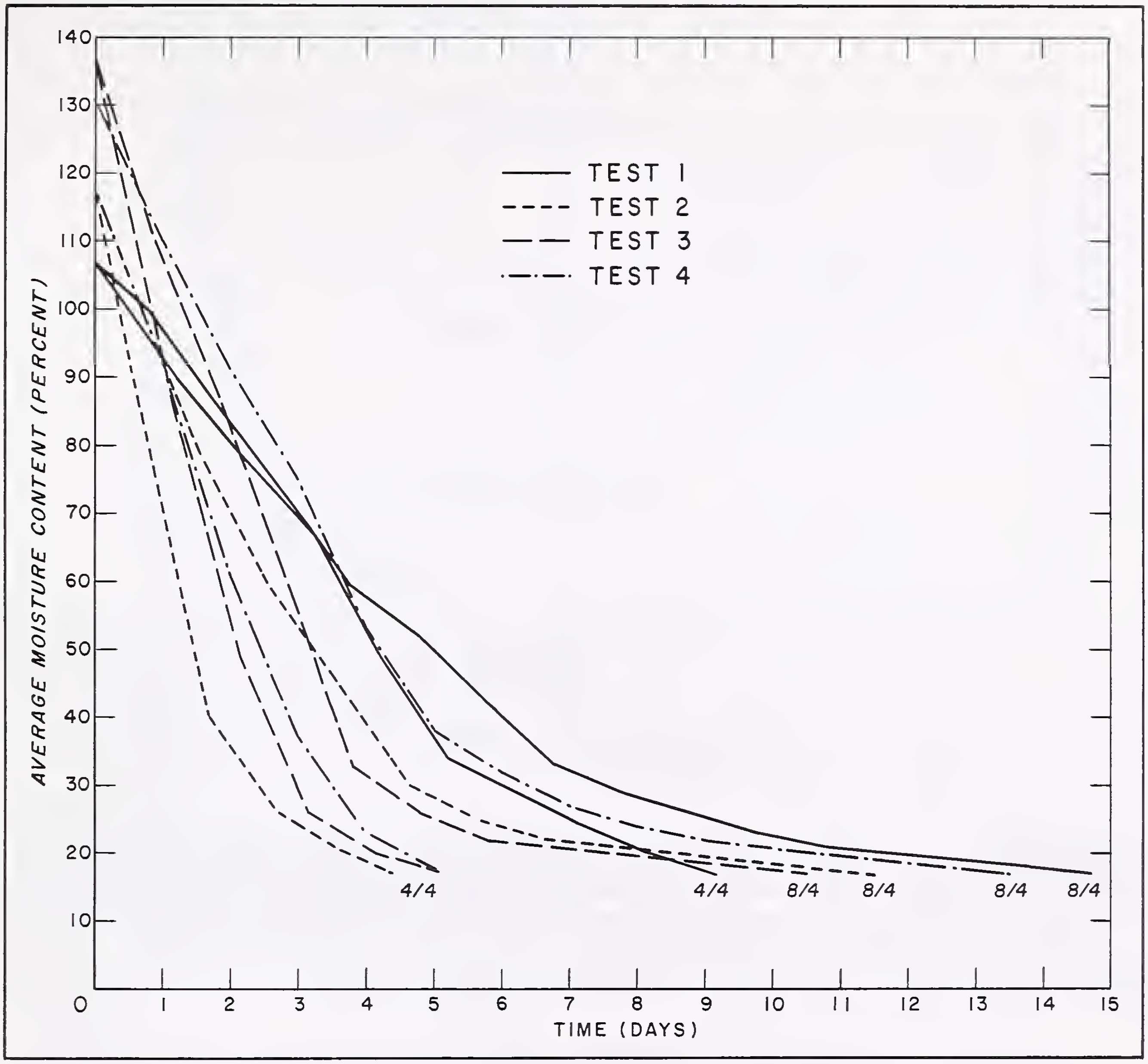

Figure 7.--Pine lumber (4/4 and 8/4) dried together at air velocities of approximately 600 f.p.m. and constant temperature (80° F.).

Drying without additional heat,when outside temperatures are decreasing and drying is slow, is not usually desirable because of the danger of blue stain. This is illustrated in figure 8 by a test in which no heat was added, temperatures were cool, humidities higher than normal because of rain, and with air velocities of 200 f.p.m. Mold appeared on some boards on the sixth day and by the end of the test blue stain degraded 44 percent of the total load at least one lumber grade.

Results in conventional dry kilns clearly show that temperatures of 180° to 200° F. increase drying rates tremendously. Thus, at these temperatures southern pine is kiln-dried commercially from green to 12 to 15 percent moisture content in 3 days. In forced air-drying, however, the objective is to use as little heat as possible in order to keep down the cost of the building, heat-

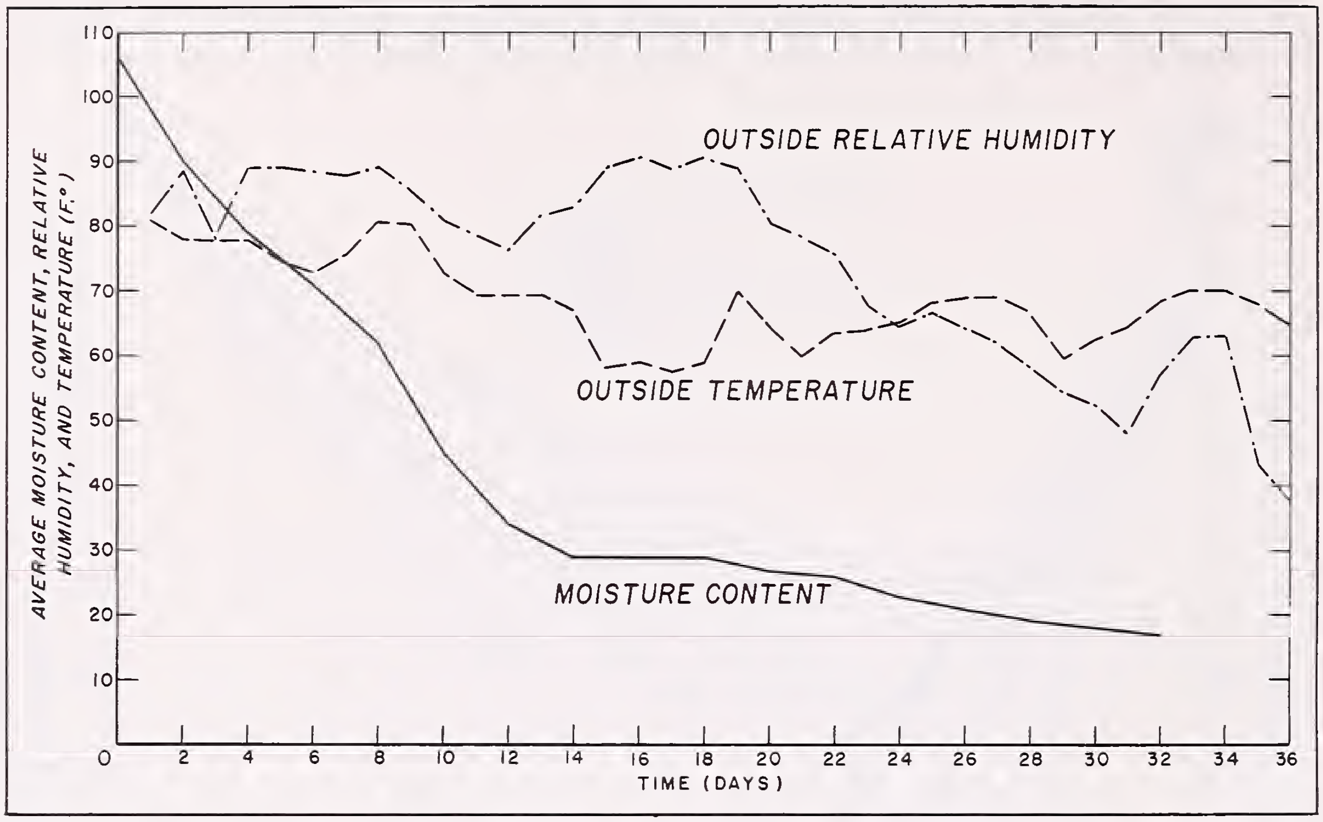

Figure 8.--Pine lumber (4/4) dried in the fall at 200 f.p.m. air velocity in the kiln with no temperature control.

ing facilities, and fuel. The use of temperatures higher than described in these tests (within the limits of necessary humidity control) will speed drying and is limited only by what commercial operators find economical.

Control of Equilibrium Moisture Content Conditions

Air must be partially dry in order to absorb the moisture given off by wood in drying, regardless of air velocities and temperatures. As air approaches saturation, drying slows down or stops. The moisture for saturation can come from the wood being dried or from humid incoming air, or from both. Thus, in order to maintain rapid drying during periods of wet weather, steps must be taken to increase the moisture-holding capacity of the air. This is most easily and economically done by increasing the air temperature so it will hold more moisture. A cubic foot of air at 92° F. will hold twice as much moisture as a cubic foot of air at 70° F. The function of controlling EMC conditions, therefore, is to maintain the drying capacity of the air by adding heat only when necessary. This method is particularly effective and necessary during rainy or humid weather.

Numerous tests made with maximum EMC's of 12.6 percent or less and average air velocities of 600 feet per minute resulted in drying 4/4 pine in 3.3 to 5.5 days from green to an average moisture content of 17 percent (fig. 9).

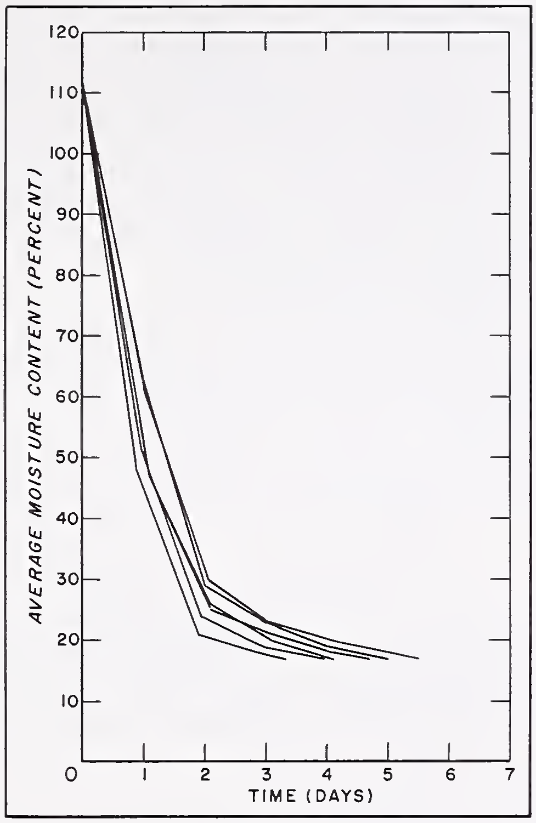

Figure 9.--One-inch pine lumber dried at six EMC conditions from 9.7 percent to 12.6 percent with a constant air velocity of 600 f.p.m.

Temperatures required to maintain a given EMC setting were lower in the winter, and again showed the need for maintaining a minimum temperature in order to assure rapid moisture diffusion to the surface of the lumber, even though the air was dry. To assure adequate air dryness, controls should be set for a maximum EMC of 11 percent and combined with a minimum temperature to provide satisfactory moisture diffusion and evaporation during all seasons.

Air Velocity

Movement of air in the drying of wood is necessary for two reasons: (1) removal of moisture evaporated at the surface of the wood and (2) replacement of the moisture-laden air with drier air so that drying can continue. Drying time is reduced as air velocity is increased up to the point when moisture is being carried away as fast as it reaches the surface.

The effect of air velocities on reduction of drying time is most clearly illustrated in the wind tunnel tests where three velocities were tested simultaneously so as to minimize all other variables. In these tests, air velocities of 300, 550, and 800 feet per minute were used during several seasons (fig. 5). In the spring months the drying times for these air velocities were 7.5, 5.8, and 4.4 days, respectively, from the green condition down to a moisture content of 25 percent. Comparable tests during the winter required 12.0, 10.0, and 7.0 days. These results indicate a reduction of 1 to 3 days drying time per 200 to 250 feet per minute increase in air velocity.

Results of air velocity tests in the kiln showed how fan power required to produce various air velocities was related to drying time. The average daily consumption of electricity was 52, 83, and 148 kilowatt-hours for the average air velocities of 200, 600, and 1,000 feet per minute, respectively (fig. 10). Power consumption was almost doubled when air velocity was increased from 600 to 1,000 per minute, but drying time was not reduced in proportion. Based on these tests the optimum air velocity is approximately 600 feet per minute and is justified by reduced drying time.

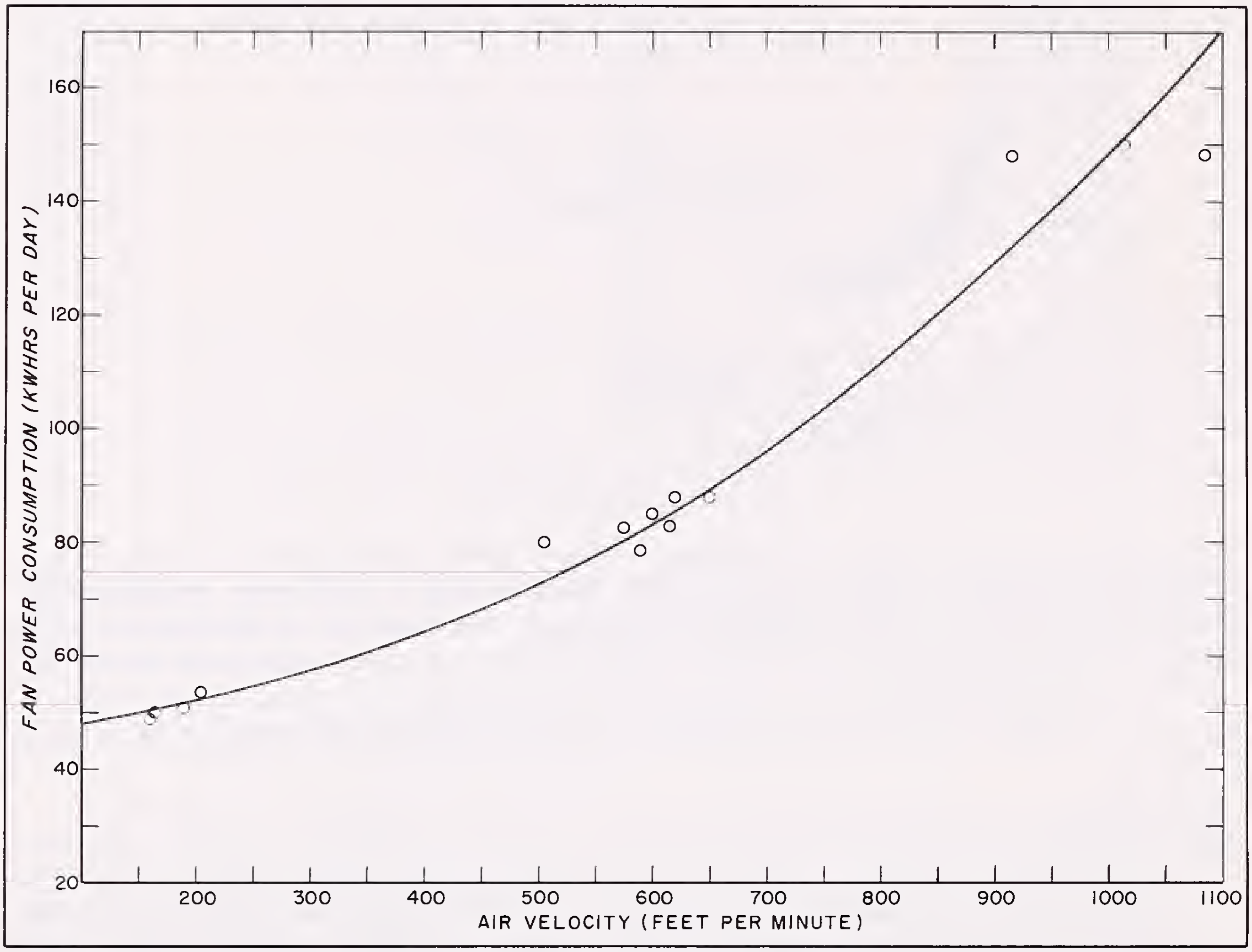

Figure 10.--Fan power consumption at various velocities in the dry kiln.

Length of Air Travel

The past experiences of lumber companies with tunnel-type forced air driers have demonstrated the hazards of structures in which air must travel an excessive distance before leaving the lumber. Air picks up moisture as it moves across the surface of green lumber and progressively loses its capacity for drying. Drying ceases entirely when the air finally becomes saturated. The distance air travels through a lumber load affects the drying time, moisture content uniformity, and degrade from stain.

Tests conducted in an extended wind tunnel revealed important differences in the drying time and condition of boards located at various positions from the air-entry end to the air-exit end. As expected, faster drying occurred at the air-entry end and was progressively slower near the air-exit end. Using a tunnel 16 feet long, with samples placed 8 feet apart at air-entry, center, and air-exit locations, drying time for 4/4 pine was 5.0, 11.3, and 14.3 days, respectively, from the green condition to an average moisture content of 30 percent (fig. 11). No heat was used and an air velocity of 500 feet per minute was maintained without change of direction. It rained on the 5th, 6th, and 7th days and heavy blue stain developed on boards at the air-exit end on the 9th day. Similar results were obtained in the second test using an identical drying setup but with additional sample boards immediately behind the boards at the air-entry side. Rain also occurred during this test beginning on the 4th day and continuing through the 8th day. On the 7th day heavy blue stain appeared on the boards.

Additional samples used in the second test permitted the approximation of maximum air travel and comparable drying rates for the drying conditions at time of test (fig. 12). Using this for illustrative purposes only, the curve permits approximation of calculated moisture contents at any place in the

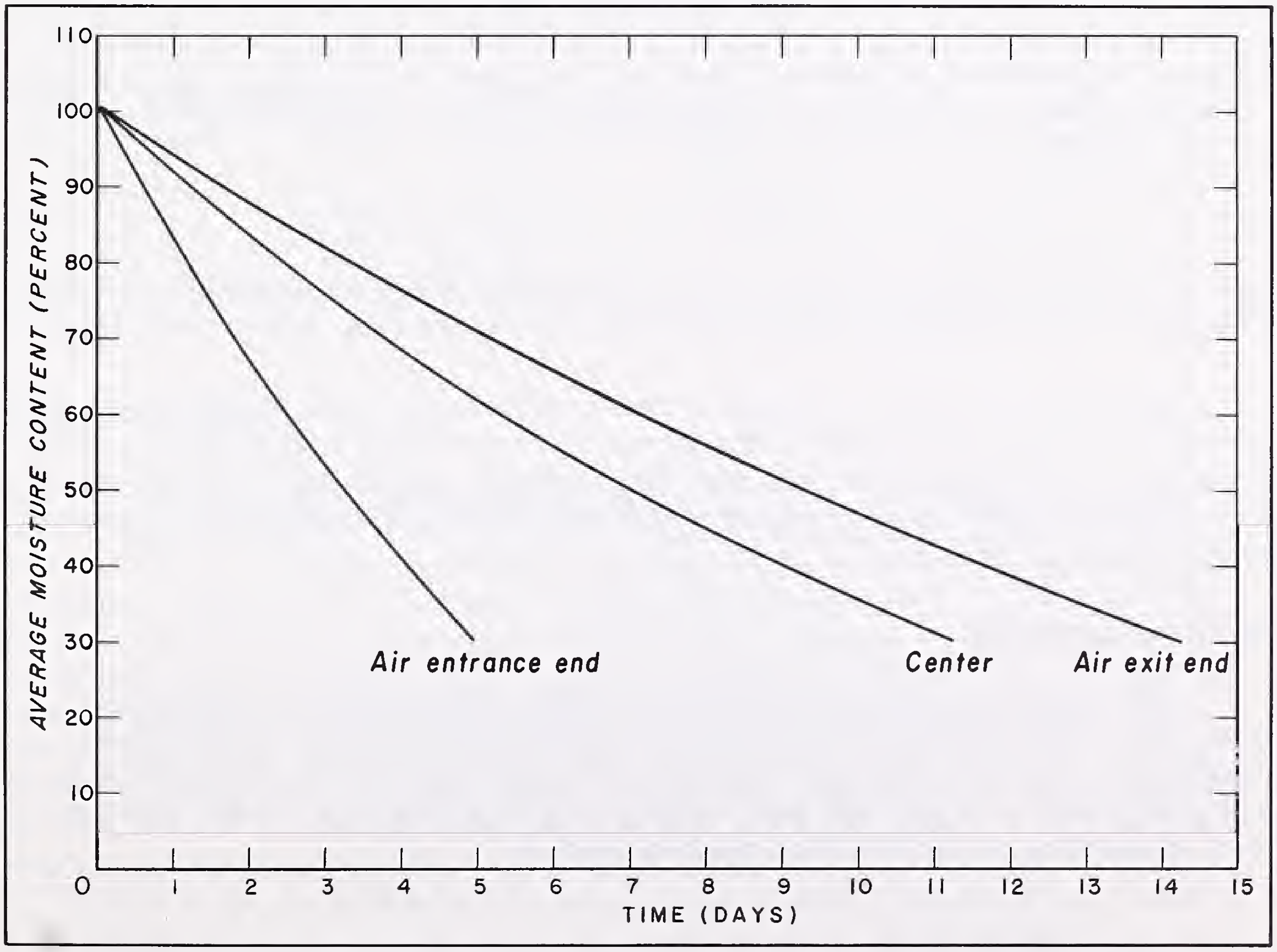

Figure 11.--Effect of length of air travel on drying time of 4/4 southern pine.

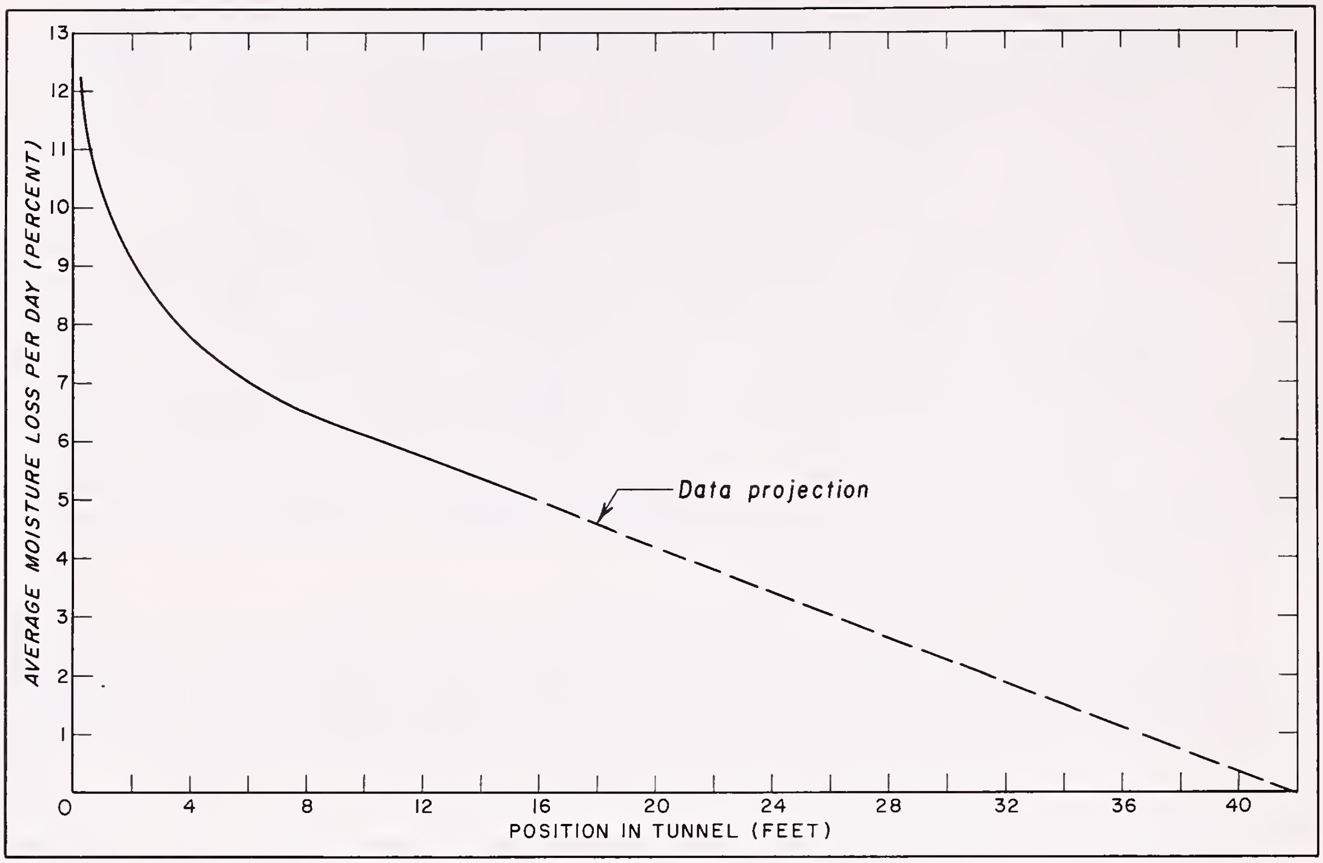

Figure 12.--Effect of length of air travel on drying rates of 4/4 southern pine. Drying time is 8 days. No control of drying conditions except air velocity (500 f.p.m.). No fan reversal.

test tunnel and approximation of the saturation point by extending the data. This test was conducted without heat and with air moving only in one direction.

Based on two tests, it appears that reversing circulation helps eliminate the large differences in moisture content and also reduces drying time. These tests were conducted in the kiln with an 8-foot air travel, with and without air circulation reversal, and resulted in reduced drying time and better moisture content uniformity (fig. 13).

Seasoning Degrade

Seasoning degrade in conventional yard drying can be expensive. Research conducted recently in Georgia indicates that the average loss resulting from all seasoning degrade in drying 4/4 pine was approximately $10 per thousand board feet and varied from $5 to $26 per thousand board feet, depending on the stacking method used.[5]

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[5] Page, Rufus H., and Carter, Roy M. Heavy Losses in Air-Seasoning Georgia Pine and How to Reduce Them. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 85, 20 pp., illus. 1957.

Results in the kiln and tunnel tests indicate that much of this loss can be eliminated by forced air-drying so long as the variables tested in this study are controlled as recommended. Ninety percent of the boards used in these tests were of the common grades described in the rules of the Southern Pine Inspection Bureau. Based on the total number of boards dried, seasoning degrade did not exceed 55 cents per thousand board feet in any test in which drying conditions were controlled. Degrade was not increased by the higher air velocities (tables 2 and 3).

Blue stain occurred in both dry kiln and tunnel tests when dried without control of drying conditions during rainy periods. In the most severe case, 44 percent of the boards were degraded because of blue stain.

Table 2.--Summary of lumber grade before and after forced air-drying southern pine

Lumber grade	Before	After
	Board feet	Board feet
B and Better	312	282
C	534	528
No. 1 Common	11,916	11,784
No. 2 Common	3,402	3,492
No. 3 Common	978	1,050
No. 4 Common	--	6
Total	17,142	17,142

Table 3. --Degrade loss in forced air-drying southern pine

Type of degrade	Amount per M bd. ft.
	Dollars
Surface checks	0.10
End checks	.10
Stain	.14
Crook	.14
Cup	.07
Average loss	.55

Moisture Content

Moisture content is an important factor in the marketing of southern pine lumber. Control of drying conditions will permit forced air-drying of 4/4 lumber to a maximum moisture content of 19 percent in 6 days or less. Dimension material, of course, requires about twice this time to reach 19 percent. Green lumber going into the dryer usually varied in moisture content from 60 to 130 percent (fig. 14). Tests in the kiln were terminated after the wettest sample board dried to 20 percent moisture content with the average final moisture content for most of the 4/4 loads usually 16 to 17 percent. Ninety-five percent of the 4/4 lumber dried under test conditions in the kiln was 20 percent moisture content and less (fig. 15). The moisture content meter readings for all 4/4 loads varied from an average minimum of 12 percent to an average maximum of 19 percent, with individual loads ranging from a minimum of 8 percent to a maximum of 25 percent.

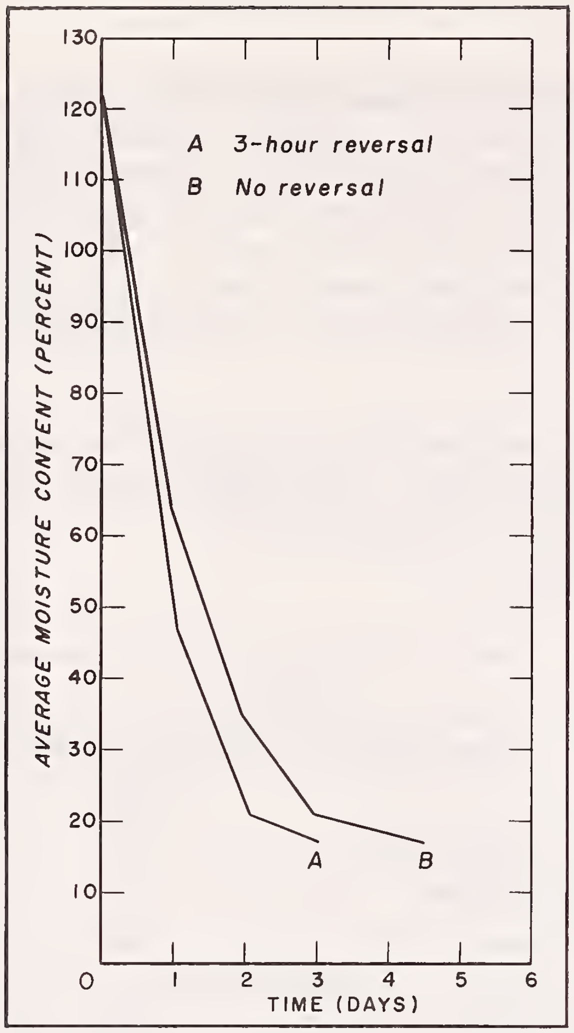

Figure 13.--Effect of air circulation reversal on drying time and moisture content of 4/4 pine lumber, both tests conducted at same EMC control conditions.

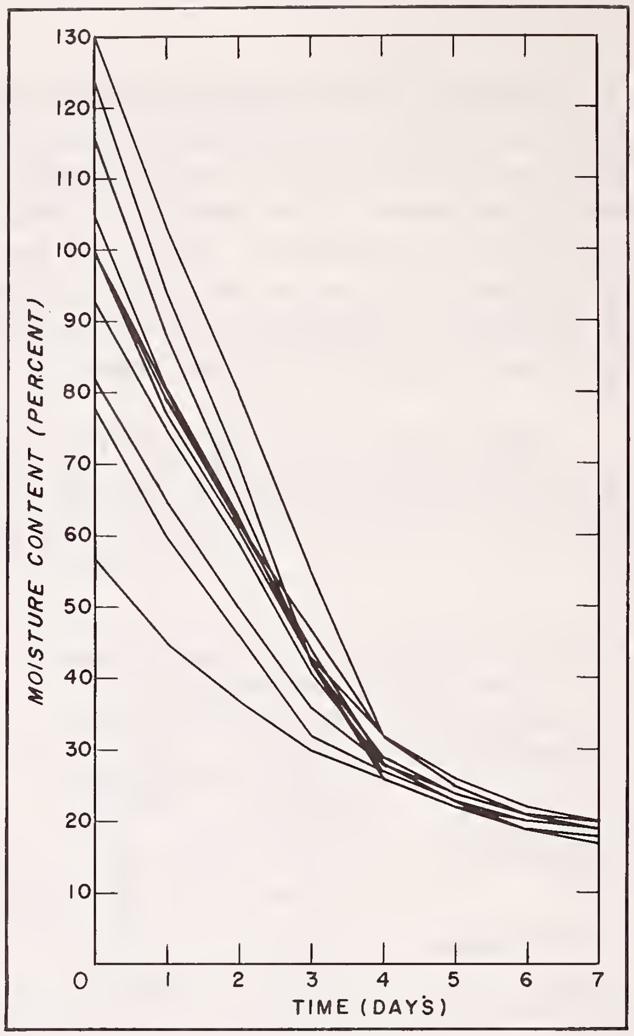

Figure 14.--Moisture-time curves of samples in a typical test illustrating the variation of moisture content. Pine (4/4) dried at 80° F. and 1,015 f.p.m. air velocity.

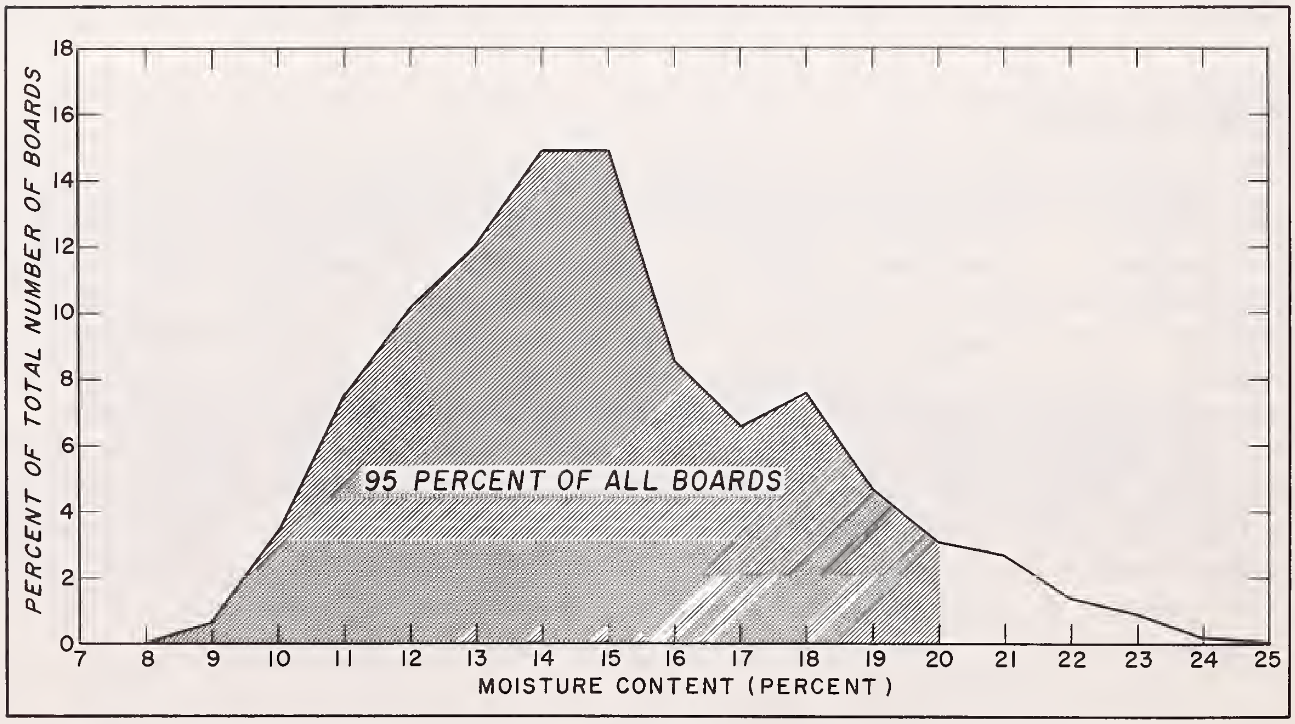

Figure 15.--Frequency distribution of all moisture meter readings (3,080 - 4/4 boards).

CONCLUSIONS

Rough, green, southern pine lumber can be rapidly dried using forced air circulation without significant degrade when drying conditions are controlled. If minimum temperatures, EMC conditions, air velocities, and length of air travel are controlled, 4/4 pine can be dried to 19 percent moisture content in 4 to 6 days. Dimension of 8/4 thickness requires an average of twice as long to dry as 4/4 lumber.

Temperature.--Moisture movement within wood increases as temperature is increased. In order to obtain a satisfactory drying rate, certain minimum temperatures must be maintained. Tests indicate that good drying rates may be obtained when using a constant temperature of 80° F. Higher temperatures (up to 110° F.) can be expected to further reduce drying time without increasing degrade. The use of temperatures higher than 80° F. is desirable and limited only by what the operator finds economical. During favorable spring and summer weather good drying can be done without temperature control. During the fall, when outside temperatures are going down, control of minimum temperatures is a necessary safeguard against slow drying and subsequent blue stain. Drying southern pine lumber below 25 percent moisture content without heat in cold weather appears impractical.

Control of EMC.--Control of maximum equilibrium moisture content is necessary to assure rapid evaporation of wood moisture from the surface of the wood. This type of control must be combined with minimum temperature control in order to be effective during all seasons. EMC control loses its effectiveness during cold weather without minimum temperature control because the ambient temperatures may not be high enough for good moisture diffusion. Equilibrium moisture content control is most effective in the warm months when temperatures are usually already high enough for good diffusion. To assure good drying conditions, maximum EMC control should be set at about 11 percent for pine.

A combination minimum temperature-maximum EMC control in one unit is highly desirable. This would provide more flexibility and require less attention than separate control instruments.

Similar control of EMC might be accomplished by maintaining an inside temperature of 10 to 15 degrees above outside temperatures. Although this method has not been tested, the temperature increase should establish desirable EMC conditions during all kinds of weather. In the winter months minimum temperature control (about 80° F.) would also be necessary for good diffusion. Even in the warm months, this method of EMC control should never require temperatures over 115° F. in any part of the southern pine region.

Air velocity.--Sustained air velocity is essential to the drying process in order to take away moisture evaporated at the surface of the lumber and to replace the moisture-laden air with drier air. Drying time was reduced 1 to 3 days per increase of 200 to 250 feet per minute air velocity up to 1,000 feet per minute, the maximum velocity tested. Velocities ranging from 200 to 1,000 feet per minute are progressively more satisfactory, with the higher velocities providing better uniformity of air movement and reduced drying time. Large variations in air velocities within the same building are not desirable because of the uneven drying which results. Baffling should be used to get satisfactory air velocities and uniform air movement through the lumber. Comparisons of drying time, power consumption, and air velocities indicate that good economical drying can be done using an air velocity of approximately 600 feet per minute. The use of higher air velocities is not economical because power consumption is too high for the small additional reduction in drying time.

Length of air travel.--As air travels across a load of lumber it picks up moisture and its capacity for drying is reduced. If the air travel is excessive the air becomes saturated before it leaves the load and no drying takes place. Control of length of air travel through the load is definitely necessary to maintain good EMC conditions, insure moisture content uniformity, reduce danger of blue stain, and decrease drying time. Length of air travel can cause large differences in drying time, moisture content, and degrade. The need for caution in constructing driers in which air must travel a long distance cannot be emphasized too strongly.

Seasoning degrade.--Seasoning degrade is a minor factor when EMC is controlled during periods of prolonged high humidity in drying. Without heat during these periods the danger of degrade from blue stain remains until the wood moisture content is approximately 20 percent. Grade losses in pine from conventional methods of air-drying can be reduced to a minimum by forced air-drying under controlled conditions.

Moisture content.--Control of drying conditions in forced air-drying will assure scheduling of drying to meet moisture content specifications (such as 19 percent) within short drying periods (4 to 6 days). Moisture content uniformity can be expected to be better than conventional yard drying.

Building construction and equipment.--Details of the type of building and equipment indicated by this study for satisfactory and economical forced air-drying are problems of engineering. The main features which should be considered, however, are: (1) a low-cost building of pole construction with wood sheathing; (2) large movable vents permitting open operation during favorable outside conditions; (3) large fans capable of 600 feet per minute air velocities through the load; and (4) a heating unit capable of maintaining minimum temperature of 75° F. in cold weather and temperatures of at least 10° F. above outside temperature in warm humid weather.

Economics of Forced Air-Drying

When the cost benefit factors of forced air-drying lumber are studied thoroughly, it will be seen that this method has many advantages over conventional yard air-drying. Some of these factors are tangible, and their cost or value can be determined readily in terms of dollars and cents. Many of the intangible benefits, however, are equally as important but cannot be evaluated easily in terms of money. These intangible benefits, as reported by companies already using forced air-driers, are:

1. Reduced capital investment by reducing lumber inventories.
2. Greater inventory turnover and thus more profits.
3. Reduced yard space needs.
4. Dependable timing to meet fluctuating market conditions.

All these benefits are associated with the rapid drying which can be done in forced air-driers. Brighter, flatter lumber with less seasoning defects is also one of the main benefits.

The factors which can be determined for 4/4 pine are the cost of forced air-drying, and the savings in seasoning degrade when compared with conventional yard air-drying. Limited data, obtained in operating a pilot plant commercial forced air-drier indicate that operating costs (fan power, heat, and labor) would vary from \$1.26 per M bd. ft. for fan drying to \$4.50 using fans and heat full time.

This pilot plant drier is an uninsulated wooden structure with a capacity of 30 M bd. ft. (fig. 16). Cost of the structure and equipment is approximately \$10,000. Electric power consumption for fan drying is 21 kw.-hrs. per hour and 25 kw.-hrs. per hour when the fans and heater are used. Local commercial rate is $1\frac{1}{4}$ cents per kw.-hr. Fuel consumption is 5 gallons per hour of Number 2 fuel oil. Local bulk rate is $12\frac{1}{2}$ cents per gallon. Unit costs in other areas may change the operating costs.

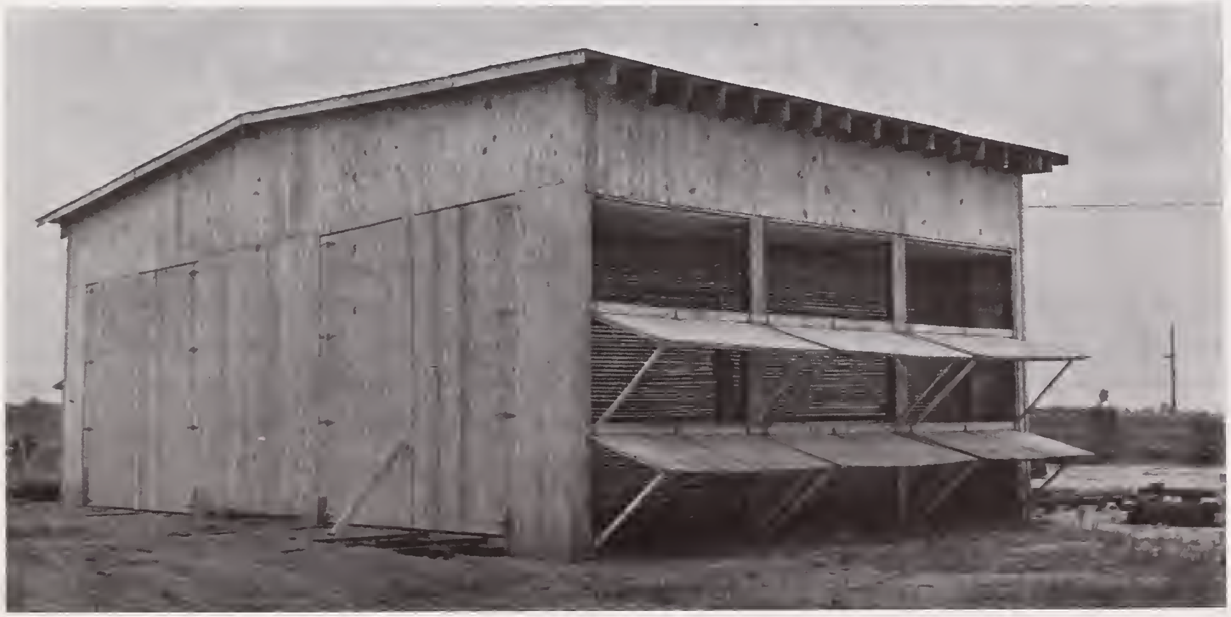

Figure 16.--Commercial forced air-drier built of pole and siding construction at Athens, Georgia.

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Annual drying capacity of the drier is approximately 1,380 M bd. ft. based on 46 weeks operation. Annual labor required amounts to approximately 400 man-hours at \$2.50 per man-hour. Maintenance and repair are set at approximately \$0.05 per M bd. ft.

Cost Estimates Based on 30 M Bd. Ft. Capacity and 6-Day Schedule

Fixed cost:

Depreciating \$10,000 at 6 percent in equal payments in 10 years = \$0.98/M bd. ft.
Maintenance and repair = .05/M bd. ft.
Total = \$1.03/M bd. ft.

Operating cost:

1. When only fans are needed--electricity costs:
   6 days x 504 kw.-hrs. x $1\frac{1}{4}$ cents/kw.-hr. = \$1.26/M bd. ft.

2. When fans and heat are needed--electricity and fuel costs:
   6 days x 600 kw.-hrs. x $1\frac{1}{4}$ cents/kw.-hr. = \$1.50/M bd. ft.
   6 days x 120 gallons x $12\frac{1}{2}$ cents/gallon = 3.00/M bd. ft.
   Total = \$4.50/M bd. ft.

In order to determine the gross drying cost, fixed costs must be added to operating costs. Fixed costs include depreciation of the structure and equipment plus an amount for repairs and maintenance. These fixed items amount to \$1.03 per M bd. ft. for the pilot plant drier and brings the gross drying cost to \$2.29 per M bd. ft. for fan drying and \$5.53 per M bd. ft. using fans and heat full time.

These figures must be deducted from the seasoning degrade savings in order to make a complete comparison. Degrade losses from conventional methods of air-drying southern pine have been found to average \$10 per M bd. ft. while the forced air-drying losses averaged only \$0.55 per M bd. ft., a difference of \$9.45 per M bd. ft. The difference between \$9.45 and the gross drying cost above indicates that \$3.92 to \$7.16 per M bd. ft. can be saved in degrade alone by forced air-drying as compared to conventional yard air-drying.

Since these calculations are based on the performance of an uninsulated structure of minimum commercial size, costs probably would be less for a more efficient structure with greater capacity. However, the savings are sufficient to warrant consideration by the progressive lumberman interested in drying on a rapid schedule with minimum seasoning losses.

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